VIII. ALHA 77005

Lherzolite, 482 grams

Weathering A, Fracturing A

Figure VIII-1. *Photograph of exterior surface of ALHA77005 showing minor fusion crust and "polished" appearance. The cube is 1 cm. (NASA # S78-31750)*

Introduction

This Martian meteorite was found partially imbedded in the ice at the Allan Hills site during one of the first collecting seasons (Yanai *et al*., 1978). It has a rounded (slightly oblate) shape and its surface was partially-ablated and roughly-polished by wind-blown ice (figure VIII-1). Only ~5% of the surface still has a thin black fusion crust (Mason, 1978, 1981). Interior voids (2-4 mm) were exposed by the saw cuts. Interior voids appear to be surrounded by shock melt. At least one small hole (1 mm) extends to the surface (T1).

Preliminary examination of ALHA77005 reported that it is ~55% olivine, ~35% pyroxene, ~8% maskelynite and ~2% opaques (Mason, 1981). The olivine (Fa_{28}) occurs as anhedral to subhedral grains up to 2 mm long. The pyroxene occurs as prismatic crystals up to 6 mm long poikilitically enclosing olivine. Maskelynite (An_{53}) is interstitial to olivine and pyroxene. Some pyroxene has undulose extinction and some shock melting has occurred.

ALHA77005 and LEW88516 have very similar mineralogy, texture and shock features (Treiman *et al.*, 1994). ALHA77005 and LEW88516 have apparently been more heavily shocked than other SNC meteorites (see below).

ALHA77005 has been extensively studied by Ishii *et al.* (1979); McSween *et al.* (1979 a,b); Berkley and Keil (1981); Ma *et al.* (1981); Shih *et al.* (1982); Reitmeijer (1983); Smith and Steele (1984); Collinson (1986); Jagoutz (1989b); Lundberg *et al.* (1990); and Ikeda (1994).

Mineral Mode

	Mason, 1981	**Treiman *et al.*, 1994**	**Ma, 1981 *(norm)***	**Wadhwa *et al.*, 1994**
Olivine	55	60.2	52	44-52
Orthopyroxene		9.5	26	
Clinopyroxene	35	3.7	11	43
Plagioclase	8	9.5	10	10-12
Ca-phosphate		0.4		tr.
Chromite	2	2.1	1	1
Ilmenite		0.5		
Pyrrhotite		0.3		
Melt		13.7		

Petrography

The ALHA77005 shergottite is a cumulate gabbroic rock consisting of brown olivine, low- and high-Ca pyroxene, plagioclase glass, Ti-poor and -rich chromite, ilmenite, whitlockite and sulfides (McSween *et al.*, 1979, Lundberg *et al.*, 1990 and Ikeda, 1994). The large sawn surface shows three lithologies: 1) lighter, 2) darker and 3) glass (figure VIII-2).

Figure VIII-2. *Photograph of sawn surface of ALHA77005,8 illustrating "light" and "dark" regions. (NASA # S78-37989)*

The saw cut shows that ALHA77005 has distinct, interpenetrating, cm-sized, light and dark regions. The textures of these regions are different. The light-colored regions are composed of large pyroxenes poikilitically enclosing euhedral to subhedral olivine and chromite grains (figure VIII-3). The low-Ca pyroxene megacrysts occur up to 5 mm across. In the dark-colored, interstitial lithology, poikilitic pyroxenes, olivine, maskelynite, small pyroxenes (both pigeonite and augite), titaniferous chromite, ilmenite, sulfides and phosphates are found. In both regions the olivine appears to be cumulus. In thin section, the olivine has a distinct brown color, apparently due to the presence of Fe^{+3}.

This rock has an igneous texture *(see the beautiful color picture of a thin section in Yanai and Kojima, 1987, page 52)*. A study of the olivine orientation by Berkley and Keil, 1981, showed that ALHA77005 is a cumulate rock that solidified in the act of flow and accumulation. However, this rock has been heavily shocked (see below).

In some areas of the meteorite, small patches of melt glass containing skeletal and hollow crystallites of olivine and dendritic chromite grains have been reported (McSween *et al.,* 1979).

Lundberg *et al.* (1990) report that the Fe/Mg of the apparently cumulus olivine is out of equilibrium with the coexisting clinopyroxene and the original calculated magmatic liquid. Longhi and Pan (1989), Lundberg

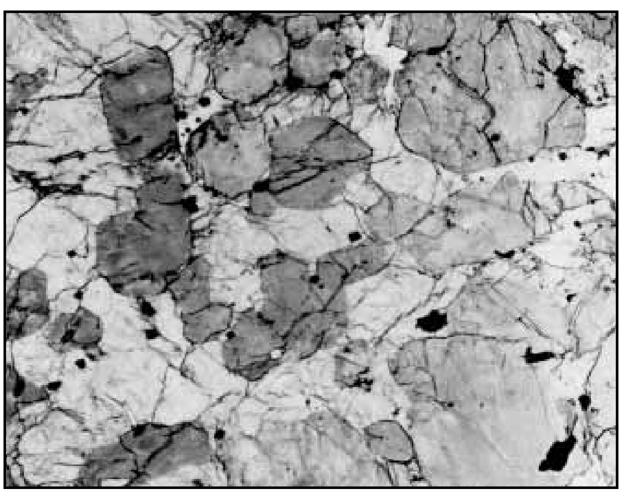

Figure VIII-3. *Photomicrograph of thin section ALHA77005,52. Large poikilitic orthopyroxene encloses euhedral olivine and chromite. Olivine is oddly colored tan to reddish-brown by minor Fe^{+3}. Field of view is 2.2 mm.*

et al. (1990) and Harvey and McSween (1992) have inferred that original Mg-rich olivine has become more Fe-rich by post-magmatic subsolidus diffusion.

Mineral Chemistry

***Olivine*:** Olivine in ALHA77005 has an unusual, distinctive pale brown color. Approximately 4.5% of the iron in the olivine in ALHA77005 is trivalent and the distinctive brown color of the olivine may be due to shock-induced oxidation (Ostertag *et al.*, 1984).

The average grain size of olivine is 1 mm with some up to 2 mm (Berkley and Keil, 1981). A weak preferred orientation of olivine grains indicates that this cumulate rock solidified during magmatic flow. Many grains have a round habit, possibly caused by reaction with intercumulus liquid. The chemical composition of olivine is homogeneous within each grain, but varies from grain to grain, ranging from Fa_{30} to Fa_{25} (Ikeda, 1994). Lundberg *et al.* (1990) have shown that this homogeneity was caused by re-equilibration with the intercumulus liquid on cooling.

Quench olivine in shock-melt pockets and veins has chemical zoning from Fa_{16}-Fa_{42}.

***Orthopyroxene*:** The large pyroxenes in the poikilitic portion of ALHA77005 show chemical zoning from high-Mg, low-Ca orthopyroxene cores to Mg-rich pigeonite with rims of ferroan pigeonite (figure VIII-4). There appears to be a compositional gap from orthopyroxene to Mg-pigeonite. Lundberg *et al.* (1990) have determined the REE composition of large poikilitic orthopyroxene grains.

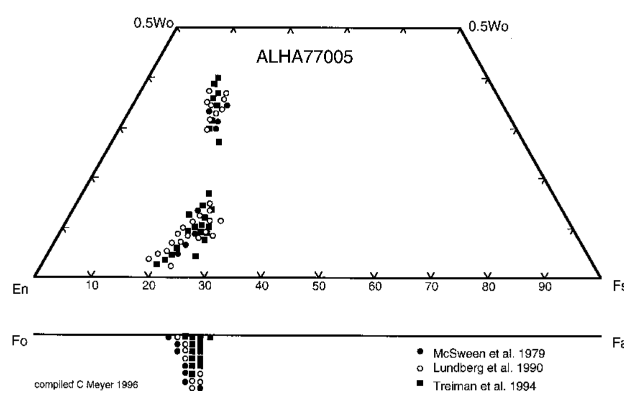

Figure VIII-4. *Composition diagram for pyroxene and olivine in ALHA77005. Data from McSween et al. (1979b), Lundberg et al. (1990) and Treiman et al. (1994).*

***Clinopyroxene*:** High-Ca pyroxene occurs in both the poikilitic and non-poikilitic portions and shows chemical zoning from sub-calcic to Ca-rich augite. Augite often occurs in contact with pigeonite, suggesting that they crystallized in close association with each other. There is no evidence of exsolution in pyroxenes. The REE composition of clinopyroxene grains has been reported by Lundberg *et al*. (1990).

Plagioclase: Maskelynite is present in areas of ALHA77005 as pseudomorphs of the original plagioclase grains and is found to have refractive indices lower than those of maskelynite in other shergottites (McSween and Stöffler, 1980; Stöffler *et al.*, 1986). In areas near the melt pockets (lithology 3), Ikeda (1994) noted that the boarders of some of the original plagioclase grains were made of rims of recrystallized Ca-rich plagioclase. Ikeda (1994) analyzed the maskelynite in ALHA77005 with broad-beam microprobe technique and found there was a compositional "gap" between the plagioclase rims and the plagioclase glass. The interpretation is that plagioclase melt produced by the shock, partially recrystallized at the rims and the remainder was quenched as glass. In other areas the maskelynite is normally zoned from An_{50-55} to An_{45-50}. Tiny vesicles are present in the plagioclase glass. Maskelynite in ALHA77005 has an average composition of An_{52} and a range from An_{24-56} (Treiman *et al.*, 1994).

Chromite: The chromite in ALHA77005 has four types of occurrence, based on differences in chemical zoning (Ikeda, 1994). McSween *et al.* (1979a) reported that as much at 10% of the iron in the chromite was Fe^{+3}.

***Ilmenite*:** McSween *et al*. (1979a) reported ilmenite with % 5 MgO.

***Whitlockite*:** Lundberg *et al.* (1990) determined the REE composition of whitlockite.

***Sulfides*:** Ikeda (1994) gives the compositions of the sulfides (both pyrrhotite and pentlandite, Ni=10%). McSween *et al*. (1979a) and Smith *et al*. (1983) reported troilite in ALHA77005, but this is probably incorrect.

Salts: McSween *et al.* (1979a) reported a FeO(OH) phase in isolated areas associated with sulfides.

Olivine, pyroxene and plagioclase compositions are also given in Yanai and Kojima, 1987, page 208.

Whole-rock Composition

Jarosewich analyzed prepared powders of both the bulk sample and of the light and dark lithologies (Jarosewich, 1990) as part of the McSween consortium. The analyses of the bulk sample and two distinct lithologies were not found to be very different, considering the difference in texture and mineralogy (table VIII-1). McSween *et al.* (1979b) found the trace element content in ALHA77005 compared closely with that in the shergottites (figure VIII-5). The high K/U, Rb/U, Cs/U and Tl/U are distinctive (almost Earth-like) when compared to basaltic achondrites.

The REE have been determined by Shih *et al.* (1982), Burghele *et al*. (1983), Smith *et al*. (1984), Treiman *et al.* (1994), and Haramura (1995) (figure VIII-6)**.** REE in the light and dark lithologies vary by a factor of about two (Treiman *et al*.). Shimizu and Masuda (1981) reported a Ce anomaly. Lundberg *et al.* (1992) found that the Ce anomaly was related to weathering of the pyroxene.

Dreibus *et al.* (1992) and Treiman *et al.* (1994) found that the composition of ALHA77005 was almost identical to that of LEW88516. Ir was found to be low — *in the range of the terrestrial upper mantle.*

Burgess *et al.* (1989) determined about 400 ppm S and Burghele *et al*. reported 600 ppm S in

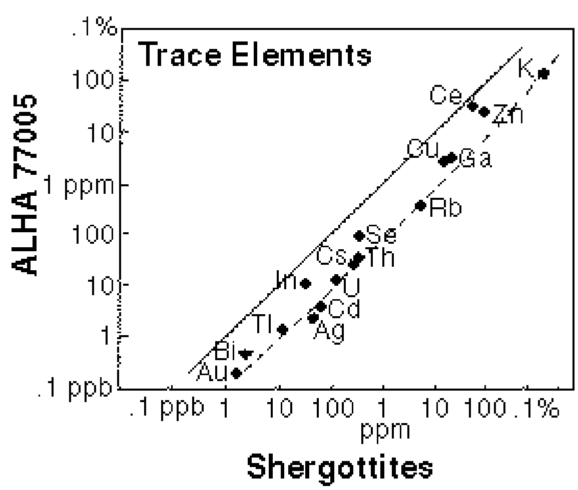

Figure VIII-5. *Comparison of the trace element composition of ALHA77005 and the average of Shergotty and Zagami. This is figure 6 in McSween et al. (1979b), EPSL* ***45****, 280.*

Table VIII-1. Chemical analyses of ALHA 77005.

	Wanke 86	**Smith 84**	**Dreibus92**	**Dreibus92**	**Jarosewich90**	**Jarosewich90**	**Jarosewich90**	**Burghele 83**	**Haramura 95**
						*dark **	*light **		
weight									
SiO2 %			43.08 (b)		42.4 (a)	41.41 (a)	45.8 (a)	43.08 (b)	43.02 (a)
TiO2		0.3 (b)	0.44 (b)		0.46 (a)	0.52 (a)	0.31 (a)	0.44 (b)	0.36 (a)
Al2O3		3 (b)	2.59 (b)		3.14 (a)	3.41 (a)	1.99 (a)	2.59 (b)	2.54 (a)
FeO	20.71 (b)	20.2 (b)	19.95 (b)		19.85 (a)	20.84 (a)	18.51 (a)	19.95 (b)	18.97 (a)
MnO	0.461 (b)	0.44 (b)	0.44 (b)		0.46 (a)	0.45 (a)	0.45 (a)	0.457 (b)	0.45 (a)
CaO	3.01 (b)	3.8 (b)	3.35 (b)		3.39 (a)	3.36 (a)	3.37 (a)	3.35 (b)	2.84 (a)
MgO		26.5 (b)	27.69 (b)		28.16 (a)	27.84 (a)	28.16 (a)	27.69 (b)	29.69 (a)
Na2O	0.597 (b)	0.48 (b)	0.44 (b)		0.48 (a)	0.6 (a)	0.27 (a)	0.438 (b)	0.37 (a)
K2O	0.033 (b)	0.028 (b)	0.027 (b)		0.04 (a)	0.04 (a)	0.02 (a)	0.027 (b)	0.03 (a)
P2O3			0.36 (b)	0.44 (d)	0.41 (a)	0.45 (a)	0.19 (a)	0.36 (b)	0.39 (a)
sum			**98.37**		**98.79**	**98.92**	**99.07**	**98.382**	**98.66**
Li ppm			1.31 (b)					1.31 (b)	
C			82 (b)		200	100	200	82 (b)	
F			22 (b)					21.9 (b)	
S			600 (b)					600 (b)	
Cl			14 (b)					14 (b)	
Sc	20.1 (b)	22 (b)	21.1 (b)					21.1 (b)	
V		158 (b)	158 (b)						
Cr	6700 (b)	5679 (b)	6568 (b)		7184 (a)	6090 (a)	7390 (a)	6589 (b)	6842 (a)
Co	75.2 (b)	69 (b)	69.5 (b)					69.5 (b)	
Ni	340 (b)	320 (b)	370 (b)		100	300	300	335 (b)	240 (a)
Cu		5.5 (b)	4.4 (b)						
Zn	62 (b)	49 (e)	71 (b)					71 (b)	
Ga	8.9 (b)	6.1 (e)	7.5 (b)					7.5 (b)	
Ge									
As		0.0014(e)	0.022 (b)					0.022 (b)	
Se		0.15 (e)	<0.4 (b)					<0.4 (b)	
Br			0.085 (b)					0.069 (b)	**Shimizu 81**
Rb		0.63 (b)	0.63 (b)	0.75 (d)					0.633 (c)
Sr		15		14.1 (d)				100 (b)	8.06 (c)
Y				6.18 (d)					
Zr				19.5 (d)					
Nb				0.57 (d)					
Mo	0.2 (b)								
Pd ppb									
Ag ppb		4.4 (e)							
Cd ppb		6 (e)							
In ppb		11 (e)							
Sb ppb	<50 (b)	0.68 (e)						<60 (b)	
Te ppb		0.5 (e)							
I ppm			1.72 (b)					1.72 (b)	
Cs ppm		0.038 (b)	0.04 (b)	0.037 (d)					
Ba		5.3 (b)		4.64 (d)					3.45 (c)
La	0.49 (b)	0.32 (b)	0.32 (b)	0.37 (d)				0.32 (b)	0.1812(c)
Ce	1.6 (b)	0.84 (b)	1.09 (b)	1 (d)				1.09 (b)	0.758 (c)
Pr		0.13 (b)							
Nd	1.9 (b)	0.82 (b)	1.15 (b)	0.8 (d)				1.15 (b)	0.399 (c)
Sm	0.67 (b)	0.46 (b)	0.42 (b)	0.47 (d)				0.42 (b)	0.226 (c)
Eu	0.288 (b)	0.22 (b)	0.2 (b)	0.22 (d)				0.2 (b)	0.1187(c)
Gd	1.1 (b)	0.92 (b)							0.44 (c)
Tb	0.19 (b)	0.18 (b)	0.17 (b)	0.16 (d)				0.17 (b)	
Dy	1.3 (b)	1.16 (b)	0.96 (b)	1.1 (d)				0.96 (b)	0.569 (c)
Ho	0.28 (b)	0.27 (b)	0.22 (b)	0.25 (d)				0.22 (b)	
Er		0.66 (b)							0.336 (c)
Tm	0.12 (b)	0.09 (b)	0.08 (b)	0.094 (d)				0.08 (b)	
Yb	0.73 (b)	0.55 (b)	0.52 (b)	0.52 (d)				0.52 (b)	0.315 (c)
Lu	0.1 (b)	0.077 (b)	0.073 (b)	0.076 (d)				0.073 (b)	0.0461(c)
Hf	0.78 (b)	0.58 (b)	0.55 (b)	0.57 (d)				0.55 (b)	
Ta	0.033 (b)		0.026 (b)					0.026 (b)	
W ppb			84 (b)					84 (b)	
Re ppb									
Os ppb									
Ir ppb	4 (b)		3.5 (b)					3.5 (b)	
Au ppb	1.3 (b)	0.29 (e)	0.3 (b)					0.3 (b)	
Tl ppb		1.7 (e)							
Bi ppb		(0.7 (e)				**Chen and Wasserburg 86**			
Th ppm	<0.1 (b)		<0.1 (b)	0.53 (d)		0.058 (c)		<0.1 (b)	
U ppm	<0.04 (b)	0.029 (e)	<0.05 (b)	0.012 (d)		0.015 (c)		<0.05 (b)	

technique: *(a) wet chem., (b) INAA & RNAA, (c) isotope dilution mass spec., (d) spark source mass spec., (e) RNAA, (f) INAA, (g) ICP-OES"*
** from powder prepared by Jarosewich*

Table VIII-1. Chemical analyses of ALHA 77005 continued.

	Treiman94	**Trieman 94** *light **	**Trieman 94** *dark **	**McSween79**	**Ma 81**	**Ma 81**	**Shih 81**	**Warren96**	**Onuma81**	**Onuma81**	**Jagoutz89**
weight	*calculated*	*70 mg*	*74 mg*		*311 mg*	*42.7 mg*					87 mg
SiO2 %	40.8										
TiO2	0.61										
Al2O3	3.8										
FeO	21.7	18.4 (f)	21 (f)								
MnO	0.48										
CaO	2.9	3.4 (f)	3.5 (f)								
MgO	28										
Na2O	0.63	0.296 (f)	0.586 (f)								
K2O	0.04	0.02 (f)									
P2O3	0.34										
sum	**99.3**										
Li ppm							1.58 (c)				
C											
F											
S											
Cl											
Sc		22.2 (f)	22 (f)		22 (f)						
V					158 (f)						
Cr		8142 (f)	6979 (f)								
Co		67.4 (f)	77 (f)	67.2 (e)	70 (f)						
Ni		320 (f)	340 (f)		320 (f)			298 (e)			
Cu				5.47 (e)							
Zn				49.4 (e)				58 (e)			
Ga				6.07 (e)							
Ge								0.58 (e)			
As				0.0014(e)							
Se			0.5 (f)	0.149 (e)							
Br											
Rb				0.626 (e)			0.783 (c)				0.783(c)
Sr						16 (e)	14.1 (c)		6.2 (f)	6.3 (f)	16.4 (c)
Y											
Zr											
Nb											
Mo											
Pd ppb											
Ag ppb				4.37 (e)							
Cd ppb				5.92 (e)							
In ppb				11.1 (e)							
Sb ppb				0.69 (e)							
Te ppb				0.45 (e)							
I ppm											
Cs ppm		0.03 (f)	0.05 (f)	0.038 (e)							0.083(c)
Ba						6 (e)	4.53 (c)		2.4 (f)	2.3 (f)	
La		0.21 (f)	0.51 (f)		0.33 (f)	0.33 (e)	0.314 (c)				
Ce			2.6 (f)			0.94 (e)	0.74 (c)				
Pr						0.13 (e)					
Nd						0.88 (e)	0.76 (c)				1.119(c)
Sm		0.29 (f)	0.63 (f)		0.46 (f)	0.46 (e)	0.45 (c)				0.631(c)
Eu		0.134 (f)	0.89 (f)		0.21 (f)	0.23 (e)	0.224 (c)				
Gd						0.92 (e)					
Tb		0.13 (f)	0.2 (f)			0.18 (e)					
Dy					1.1 (f)		1.16 (c)				
Ho						0.27 (e)					
Er							0.66 (c)				
Tm						0.09 (e)					
Yb		0.4 (f)	0.71 (f)		0.53 (f)	0.58 (e)	0.54 (c)				
Lu		0.055 (f)	0.099 (f)		0.078 (f)	0.08 (e)	0.074 (c)				
Hf		0.42 (f)	0.81 (f)		0.58 (f)						
Ta		0.02 (f)	0.04 (f)								
W ppb											
Re ppb								0.102 (e)			
Os ppb								4.4 (e)			
Ir ppb		6 (f)	3.3 (f)					4.1 (e)			
Au ppb		3.6 (f)	1.5 (f)	0.288 (e)				0.26 (e)			
Tl ppb				1.7 (e)							
Bi ppb				<0.72 (e)							
Th ppm				0.059 (e)							
U ppm				0.018 (e)		0.04 (e)					

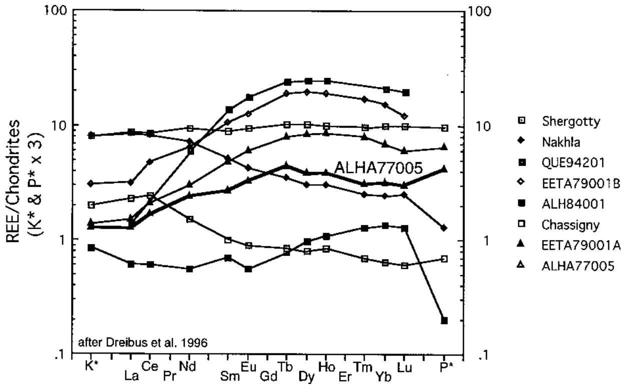

Figure VIII-6. Normalized rare-earth-element composition diagram comparing ALHA77005 with the other Martian meteorites. This figure is redrafted from Dreibus et al. (1996).

ALHA77005. Gooding *et al.* (1990) determined the thermal release pattern for several volatile species.

Shock Features

ALHA77005 has been more heavily shocked than the other SNC meteorites. Maskelynite is found to have refractive indices lower than that in other shergottites (McSween and Stöffler, 1980; Stöffler *et al.*, 1986). Ikeda (1994) reported that all of the olivine and pyroxene showed mosaic extinction under the microscope. McSween and Stöffler found that irregular shock-melt pockets and pseudotachylite veins comprise up to 20% by volume of the rock. Stöffler *et al.* (1986) concluded that ALHA77005 reached equilibrium shock pressure of 43 ± 2 GPa and post-shock temperature of 400 - 800°C. Bishoff and Stöffler (1992) have also studied the shock features in ALHA77005 and Rietmeijer (1983) discussed "shock-induced chemical reactions."

Magnetic Studies

The anhysteretic remanent magnetization (ARM) technique for the determination of the paleomagnetic field on Mars has been attempted on ALHA77005 (Nagata, 1980, Collinson, 1986), but the results are inconclusive (Sugiura and Strangway, 1988). The presence of Fe^{+3} in the magnetic phases (titanomagnetite) may help this experiment, but the high shock pressures and complicated histories of SNC meteorites may have disturbed any natural remanent magnetism (NRM), making this important experiment very challenging. If the shock event induced enough reheating, the original NRM may have been erased and re-acquired at the time of shock (Sugiura and Strangway, 1988). Nagata (1980) reported a small amount of metallic iron in his magnetic studies, but this can not be in equilibrium with the original mineral assemblage.

Radiogenic Isotopes

Shih *et al.* (1982) reported a Rb-Sr age of 187 ± 12 Ma with $^{87}Sr/^{86}Sr = 0.71037 \pm 5$ (figure VIII-7) ($\lambda_{RB} = 1.39 \times 10^{-11}$ $year^{-1}$)and a Sm-Nd age of ~ 325 Ma. Schaeffer and Warsila (1981) obtained a vague $^{40}Ar/^{39}Ar$ plateau age of about 1.1 Ga. However, Jessberger *et al.* (1981) used laser probe extraction to show that excess ^{40}Ar is located inhomogeneously within the minerals of ALHA77005. Jagoutz (1989b) determined an age of 154 ± 6 Ma ($^{87}Sr/^{86}Sr = 0.71042 \pm 2$) using Rb/Sr isochron between two pyroxenes (figure VIII-8). He also determined an age of 15 ± 15 Ma for the shock event. Jagoutz argued that 154 Ma is the age of the igneous event, because the pyroxenes were unaffected by the shock.

Cosmogenic Isotopes and Exposure Ages*

The terrestrial residence age as reported by Schultz and Freundel (1984) is 190 ± 70 thousand years. Evans

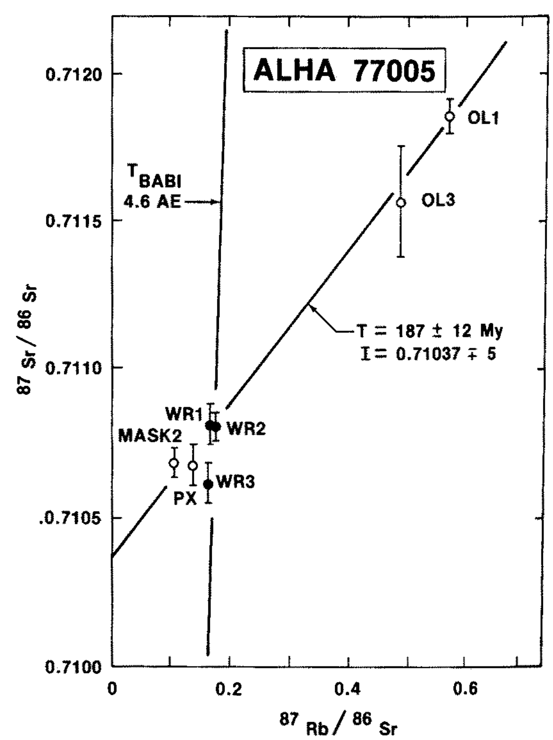

*Figure VIII-7. Rb-Sr isochron diagram for mineral separates and whole rock samples of ALHA77005. This is figure 3b in Shih et al. (1982), GCA **46**, 2328.*

*Data for Allan Hills #5 (76005) has sometimes been confused with that of ALHA77005 (e.g. Ashwal and Wood 1981, Kirsten et al. 1978).

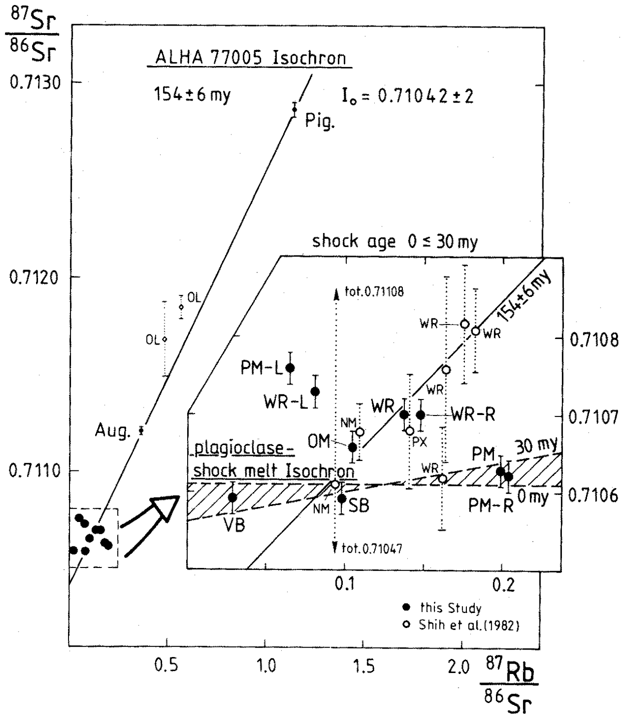

Figure VIII-8. *Rb-Sr isochron diagram for ALHA77005. This is figure 7 in Jagoutz (1989b), GCA* ***53****, 2435.*

et al. (1992) provide the activity of ^{26}Al, ^{10}Be, ^{53}Mn, ^{35}Cl and ^{14}C and also give a terrestrial age of 190 ± 70 thousand years.

Nishiizumi *et al.* (1986) reported a ^{10}Be exposure age of 2.5 ± 0.3 Ma. Pal *et al.* (1986) determined an exposure age of 2.8 ± 0.6 Ma using ^{10}Be. Miura *et al.* (1995) determined 2.9 ± 0.7 Ma and Bogard *et al.* (1984b) determined ~2.6 Ma. From cosmic-ray produced ^{3}He, ^{21}Ne and ^{38}Ar, Eugster *et al.* (1996) derived an exposure age for ALHA77005 of 3.4 Ma and concluded that ALHA77005 was *"ejected from Mars simultaneously with .... LEW88516 (3.6 Ma)."*

Other Isotopes

Bogard *et al*. (1984b) reported that the ^{129}Xe was not enriched in ALHA77005.

Chen and Wasserburg (1986b) studied the U-Th-Pb isotopic system and Harper *et al.* (1995) reported the isotopic composition of ^{142}Nd/^{144}Nd.

Garrison *et al.* (1995) studied the Ne isotopic system and determined that ALHA77005 was exposed to solar-flare protons.

Clayton and Mayeda (1996) give the isotopic data for oxygen (figure I-2)

Gao and Thiemens (1990) determined the isotopic composition of two different S components in ALHA77005.

Processing

Initially a chip (~25 grams) was taken from the S1 face. In 1978, the first saw cut divided the sample into roughly two halves (,8 and ,9). One half (,8; 212 grams) immediately went to Japan, because the 1977 Antarctic field trip was a joint U. S. - Japan mission (Yanai and Iguchi, 1981). A second bandsaw cut was made a right angles to the first (figure VIII-9) revealing several drusy interior cavities (figure VIII-10). In 1986, sub-sample ,9 was further sub-divided.

Figures VIII-11 and VIII-12 show the relationship of the various sub-samples of ALHA77005 and the experiments made on them. More than twenty six thin sections have been made (table VIII-2). Thin sections of this Martian rock are included in the Japanese Educational Thin Section Set (see Kubovics *et al.*, 1995).

Hap McSween organized a consortium to study ALHA77005. Subsample ,38 was a bulk sample (10.1g) made from chips which fell off in initial sawing in 1978. It was homogenized and distributed to consortium members. The meteorite was restudied by the McSween consortium in 1986 when splits of a dark (,89; 5.2g) and light (,90; 5.0g) lithologies were taken and homogenized by Jarosewich (AMN 13(1) p134). The remainder of these samples are available to investigators by request to MWG. These two lithologies are intergrown and there proved to be only a minor REE difference between them (see Chemistry section).

Figure VIII-9. *Photograph of pieces of ALHA77005 after sawing in 1978. (NASA # S78-37990)*

Figure VIII-10. *Photograph of sawn surface exposed by second saw cut of ALHA77005. Note the large vesicles in the melted portions of the interior. (NASA # S78-37987)*

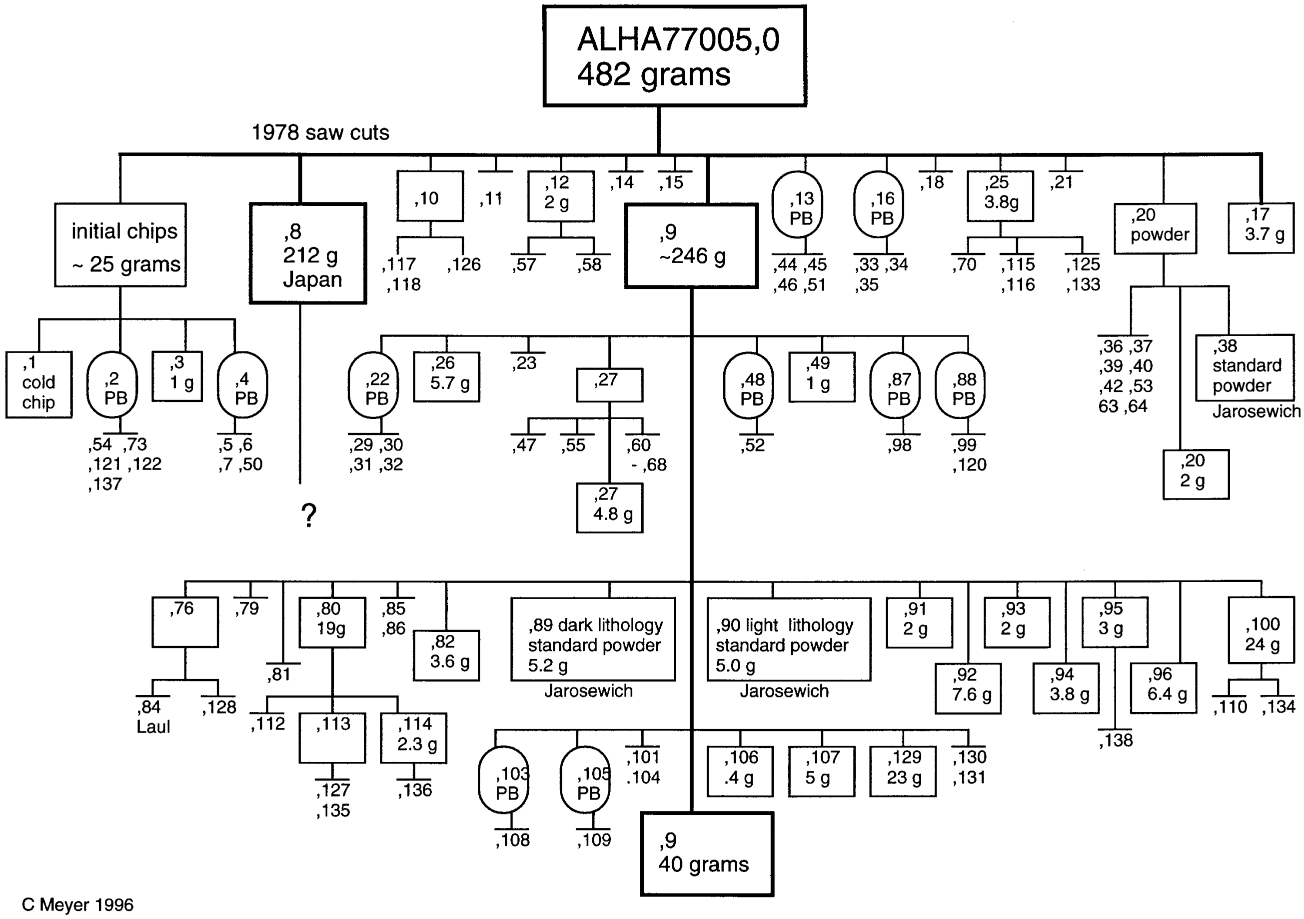

Figure VIII-11. *Genealogy diagram of allocation and splitting of ALHA77005, prior to 1996.*

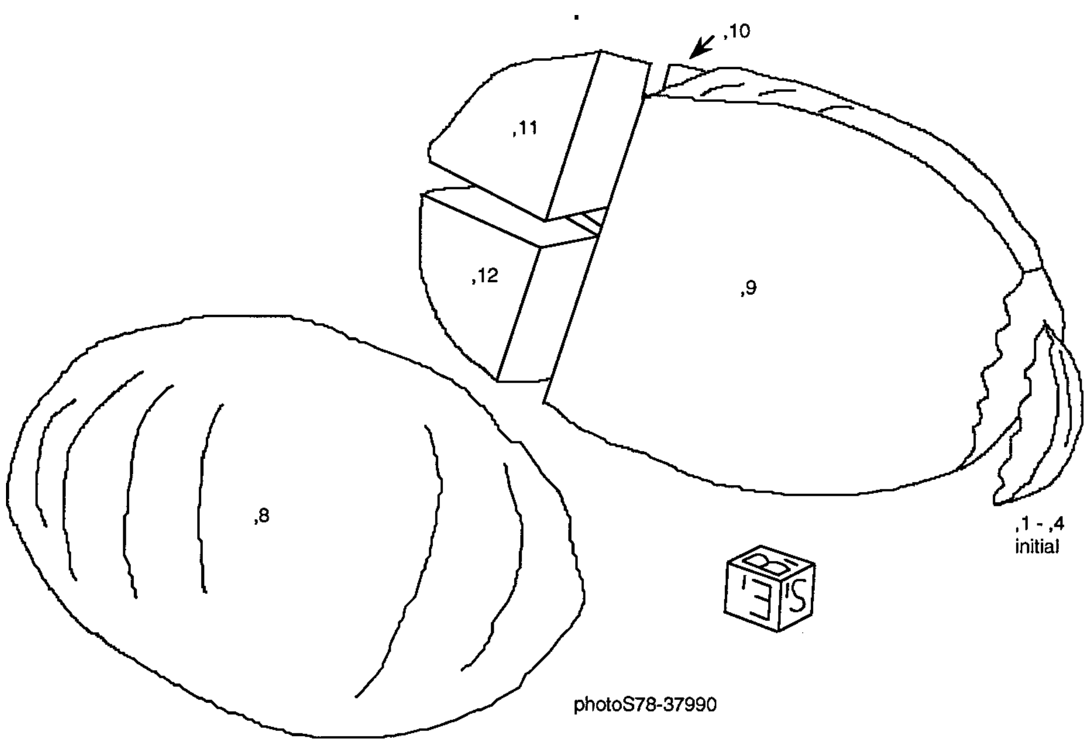

Figure VIII-12. *Schematic sketch of ALHA77005.*